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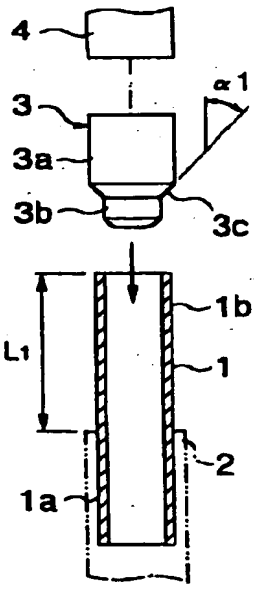
(54) Method of wall-thickening metal pipes

(57) To produce a metal pipe which has a desired region of increased thickness with an outer diameter identical to or substantially identical to the outer diameter of the remaining portion by means of cold working with utmost ease and saved cost, a method of processing metal pipes into a thick-walled structure is comprised of a first stage in which a punch (3) provided with a tapered portion is inserted into a starting metal pipe (1) at one of both ends thereof, thereby forming a diametrically expanded region thereat, and a second stage in which the expanded region of the pipe is inserted into a contracting die (5) provided with a tapered portion (5b), thereby contracting the expanded region at a given outer diameter.

FIG. 1A



EP 0 811 444 A1

Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

This invention relates to a processing method of metal pipes and in particular to a method of bringing metal pipes into a thick-walled structure.

DESCRIPTION OF THE RELATED ART

with regard to exhaust pipes and similar pipes of automotive vehicles, a base or starting metal pipe used therefor has in some cases been subjected to increased thickness at its joint portion which is required to be mechanically strong, but with the remaining portion left intact in its original wall thickness. Thus, the finished pipe allows weight savings as a whole.

A method of wall-thickening a metal pipe as noted above has heretofore been known in which a starting metal pipe is partially heated and axially compressed into a thick-walled structure. In this instance, however, the processing apparatus including the heating unit and the like is bulky and complicated, and what is worse, a uniform wall thickness is difficult to attain.

In order to overcome the above problems, a certain method of processing a metal pipe into a thick-walled structure has been proposed as disclosed in JP-A-07-214148. This method is constituted with a first step in which a starting metal pipe is caused to be inserted at its one or front end portion into a contracting die with a forced load applied to another or rear end portion, thereby reducing the front end portion in its diametral size, and the resultant front end portion is further contracted by application of a force that is smaller than and opposite to the above forced load, and a second step in which the pipe obtained in the first step is inserted into an outer die which binds the pipe to the outer diameter of the starting pipe and a mandrel is inserted into the front end portion contracted in the first step with an axial force applied out of the latter so that the outer diameter of the front end portion is expanded up to that of the starting metal pipe.

However, according to the method taught by the above cited publication, the first or metal pipe-contracting step requires a die for contracting a starting metal pipe, a mandrel used to forcibly put the pipe into the contracting die, and a die located to press the pipe on a side opposed to that put by the mandrel, while the second or metal pipe-expanding step requires, in addition to a mandrel used to expand the pipe, an outer die for binding the expanded diameter of the pipe to that of the starting metal pipe. This leaves the problem that savings are difficult to achieve in respect of process equipment and production cost.

SUMMARY OF THE INVENTION

Accordingly, the present invention in a principal object provides a method of bringing a metal pipe into a thick-walled structure which is capable of cold processing with utmost ease and moreover is conducive to savings of the equipment investment and the production cost to a conspicuously great extent.

With a view to eliminating the problems of the prior art discussed above, one important aspect of the present invention lies in the provision of a method of processing a metal pipe into a thick-walled structure which comprises: a first stage including at least one process step, in which a punch provided with a tapered portion is inserted into a starting metal pipe at one of both ends thereof, thereby forming a diametrically expanded region thereat; and a second stage including at least one process step, in which the expanded region of the pipe formed in the first stage is inserted into a contracting die provided with a tapered portion, thereby contracting the expanded region at a given outer diameter.

According to another aspect of the invention, the tapered portion of the punch used in the first stage is set to have an angle in a range from 30 degrees to 60 degrees.

In the practice of the present invention, a starting metal pipe is diametrically expanded by means of the tapered punch in the first stage, and to this end, the punch has a given angle of tapering, say between 30 degrees and 60 degrees. In consequence, a metal material present in the expanded region of the starting metal pipe is apt to be axially pressed into a state of increased thickness at that region.

In the second stage, the resultant expanded region of increased thickness is inserted into a contracting die with the result that such region is contracted at a given diameter such as for example a diameter made to be identical to or substantially identical to that of the starting metal pipe. Ultimately, a processed metal pipe can be attained which has a region in a desired range of wall thicknesses and of a desired outer diameter such as for example an outer diameter rendered equal to or virtually equal to that of the starting metal pipe.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A through FIG. 1D represent one preferred embodiment of process steps according to the present invention, FIG. 1A being a side-elevational cross-sectional view of a starting metal pipe prior to processing, FIG. 1B being a side-elevational cross-sectional view of the pipe after being expanded, FIG. 1C being a side-elevational cross-sectional view of the pipe prior to contraction of its expanded region, and FIG. 1D being a side-elevational cross-sectional view of the pipe after being contracted in regard to its expanded region.

FIG. 2A through FIG. 2D represent, as side-elevational views, another embodiment of the invention in

which the first and second stages are divided, respectively, into a plurality of process steps, a starting metal pipe being subjected to expansion in a plurality of expanding steps as shown in FIGS. 2A and 2B, and the resultant expanded region being exposed to contraction in a plurality of contracting steps as shown in FIGS. 2C and 2D.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to the drawings, the present invention will now be described in greater detail.

FIGS. 1A, 1B, 1C and 1D illustrate a method of processing a metal pipe into a thick-walled structure according to the invention. In FIG. 1A, a starting metal pipe 1 is shown for ready processing and disposed in a vertical posture with one or rear end region 1a retained in a clamp 2. The rear end region 1a is not intended to be processed for increased thickness. The end-to-end distance L_1 between the other or front end region 1b and an upper end of the clamp 2 is set such that the metal pipe 1 is protected against buckling during processing for increased thickness. The front end region 1b is intended to be processed for wall thickening.

Designated at 3 is a punch provided to expand and thicken the front end region 1b, and the axis of the punch 3 is positioned in alignment with that of the metal pipe 1 and made vertically movable. The punch 3 includes an expanding die 3a having a larger diameter than the inner diameter of the metal pipe 1, a tip or lower end 3b having a diameter smaller than that of the die 3a and disposed for pressing fit to the metal pipe 1, and a tapered portion 3c interposed integrally between the die 3a and the tip end 3b. Further, the tapered portion 3c is defined to have a specific tapering angle α_1, i.e., a specific angle opened with respect to the axis of the die 3a, the angle being set at a selected one in a range from 30 degrees to 60 degrees. This specified range of angle L_1 is attributable to the fact that adequate pipe expansion and wall thickening are feasible only at 30 degrees or more, and larger angles than 60 degrees are frequently responsible for axially deformed or otherwise buckled metal pipe during forcible insertion of the die 3a into the metal pipe 1.

The punch 3 is disposed to be reciprocably, namely vertically movable relative to the metal pipe 1 by means of a hydraulic cylinder 4 located above that punch.

In such construction, the hydraulic cylinder 4 is manipulated to descend the punch 3 which is then forced to be inserted into the front end region 1b of the metal pipe 1 so that the front end region 1b is simultaneously expanded and thickened as seen in FIG. 1B. This is taken as a first stage in the method of the present invention.

When expanded by forcible insertion of the punch 3, the metal pipe 1 is generally rendered to be of reduced thickness as it is exposed to circumferential tensile loading. In the case where the tapered portion of the punch 3 is set to have a tapering angle α_1 in a range from 30 degrees to 60 degrees, axial compression loading is applied to the metal pipe 1 with the consequence that the front end region 1b of the metal pipe 1 is prevented from becoming reduced in wall thickness and conversely is rendered thick.

At a tapering angle α_1 of the tapered portion 3c in the range of 40 to 50 degrees, especially stable processing is achievable for increased thickness of the metal pipe.

Wall thickness may be represented by the following empirical formula with slight amendments made.

$$t_1 = t_0 \times (d_0/d_1)^{0.65}$$

where

t_0: wall thickness of metal pipe prior to expansion processing

t_1: wall thickness of metal pipe after expansion processing

d_0: outer diameter of starting metal pipe

d_1: outer diameter of metal pipe after expansion processing

To gain increased thickness as desired, the metal pipe can be expanded to a predetermined extent based on the above formula.

A front end region expanded and thickened in the first stage is referred to as 1c as shown in FIG. 1B. The length L_2 of the front end region thus expanded and thickened may be determined as desired by adjusting the amount of the punch 3 forcibly inserted into the metal pipe 1.

Next, with reference to the drawings in FIGS. 1C and 1D, a second stage in the method of the present invention is explained as follows. In the second stage, an expanded front end region 1c of a thickened metal pipe 1d as obtained in the first stage is constricted at an outer diameter made identical to or substantially identical to that of the starting pipe portion 1a.

In FIG. 1C, a metal pipe thickened in the first stage is designated at 1d, and the starting pipe portion 1a is vertically disposed with one or rear end region held in a clamp 2 as above described. Reference numeral 5 denotes a contracting die provided therein with a vertically extending opening 5a having an inner diameter made identical to or substantially identical to the outer diameter of the starting pipe portion 1a. The opening 5a is in alignment with the thickened metal pipe 1d.

At a lower end portion of the opening 5a, a downwardly diverged tapered portion 5b is disposed to be integral therewith.

The tapering angle α_2 of the tapered portion 5b, i.e., an angle directed to the axis of the opening 5a, is set to be gentle at below 30 degrees. A lower end portion 5c of the opening 5a has an aperture defined with a diameter larger than the outer diameter of the expanded

front end region 1c of the thickened metal pipe 1d.

In the aforementioned construction, a hydraulic cylinder 6 is manipulated to downwardly move the contracting die 5 with the metal pipe 1d retained as shown in FIG. 1D. Thus, the front end region 1c held in expanded and thickened condition is forced into the opening 5a through the tapered portion 5b, as seen in FIG. 1D. Thus, the thickened and expanded portion 1c is then caused to enter the opening 5a while it is being drawn in its outer diameter at the tapered portion 5b. The contraction diameter of the expanded front end region 1c is decided based on the inner diameter of the opening 5a. In this instance, since the tapering angle α_2 of the tapered portion 5b is set as specified above, the expanded front end region 1c invites no rise nor decline in wall thickness and is contracted, merely becoming equal to or substantially equal to the outer diameter of the metal pipe 1a.

It is preferred that the tapering angle α_2 of the tapered portion 5b of the contracting die 5 be set at from about 15 to 20 degrees to render the front end region 1c smoothly contractive. Similar reasoning is applied as such to the case where a plurality of contraction steps are employed as described later. Also in each of these steps, a tapering angle of 15 to 20 degrees is preferable.

Advantageously, therefore, a metal pipe is provided which has a uniform outer diameter throughout the entire length and includes a thickened region 1c' over a given length as shown in FIG. 1D.

The embodiment mentioned above is designed to complete expansion and contraction of a starting metal pipe by a single stage, respectively. As illustrated in FIGS. 2A, 2B, 2C and 2D, the first and second stages each can be divided into a plurality of process steps so that expansion and thickening are successively carried out in the first stage, and contraction is successively conducted in the second stage.

Furthermore, the metal pipe after being subjected to a series of processing steps for wall thickening as stated above may be repeatedly processed with use of the same set of the punch and the contracting die with the result that a thick-walled shape is obtained with improved reliability.

As regards the above cycles of processing, a metal pipe can be further annealed in conventional manner upon completion of a first processing for increased thickness, followed by removal of work hardening from the resultant pipe and by subsequent repetition of the same mode of wall thickening at the same region. This contributes greatly to further improvement in reliability. Through experiments by the present inventors, it has been found that in the case of a single processing for wall thickening, a stainless steel pipe shows a ratio of increased thickness of 15% and that in the case of a second processing for wall thickening after annealing, a ratio of increased thickness as high as 30% can be attained.

In particular, when the metal pipe is subjected to the second processing into a thick-walled structure before the annealed metal pipe is cooled, the metal pipe is processed under warm working or hot working, which can achieve the second processing of the metal pipe into a thick-walled structure more effectively.

In the foregoing embodiments, the starting metal pipe 1 or the expanded metal pipe 1d is so illustrated that it is processed in a vertical arrangement. The pipe 1 or the pipe 1d may be placed in a lateral formation with the punch 3 and the contracting die 5 disposed to be laterally reciprocable.

The method of the present invention is suitably useful not only for exhaust pipes of automotive vehicles but also for various conduits and pipes as structural parts.

As described and shown hereinabove, the method according to the present invention enables production of a metal pipe which has a thick-walled region formed at a desired length, the thick-walled region having an outer diameter made identical to or substantially identical to the outer diameter of the remaining portion. Such method can be practiced by cold working with resort to simple combination of an expanding punch and a contracting die and with freedom from a mandrel, a pressing die and an outer die, all being required in the prior art previously discussed. This is conducive to easy production and great saving in equipment investment and production cost.

To produce a metal pipe which has a desired region of increased thickness with an outer diameter identical to or substantially identical to the outer diameter of the remaining portion by means of cold working with utmost ease and saved cost, a method of processing metal pipes into a thick-walled structure is comprised of a first stage in which a punch provided with a tapered portion is inserted into a starting metal pipe at one of both ends thereof, thereby forming a diametrically expanded region thereat, and a second stage in which the expanded region of the pipe is inserted into a contracting die provided with a tapered portion, thereby contracting the expanded region at a given outer diameter.

Claims

1. A method of processing metal pipes into a thick-walled structure which comprises: a first stage including at least one step, in which a punch provided with a tapered portion is inserted into a starting metal pipe at one of both ends thereof, thereby forming a diametrically expanded region thereat; and a second stage including at least one step, in which the expanded region of the pipe is inserted into a contracting die provided with a tapered portion, thereby contracting the expanded region at a given outer diameter.

2. The method according to claim 1, wherein the tapered portion of the punch used in the first stage is set to have an angle in a range from 30 degrees to 60 degrees.

3. The method according to claim 2, wherein the tapered portion of the punch used in the first stage is preferably set to have an angle of from 40 to 50 degrees.

4. The method according to any one of claims 1 to 3, wherein the process steps of the first stage are carried out to successively expand and thicken the starting metal pipe, and the process steps of the second stage are conducted to successively contract the expanded thickened pipe.

FIG. 1A

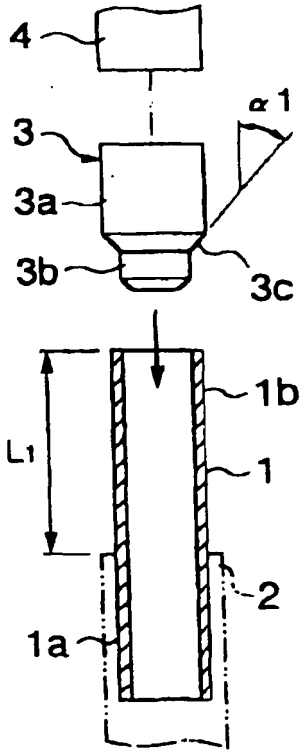


FIG. 1C

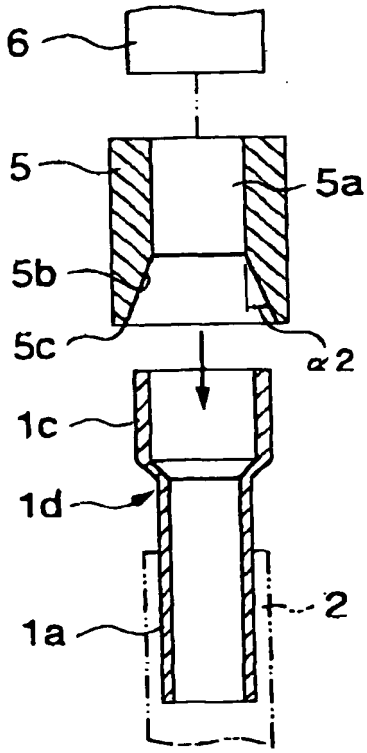


FIG. 1B

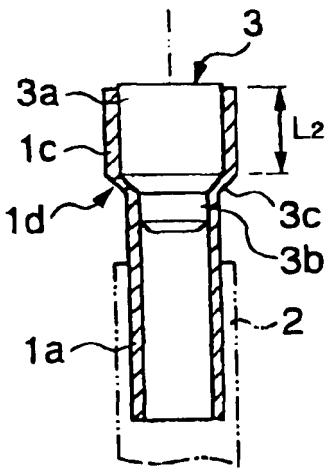


FIG. 1D

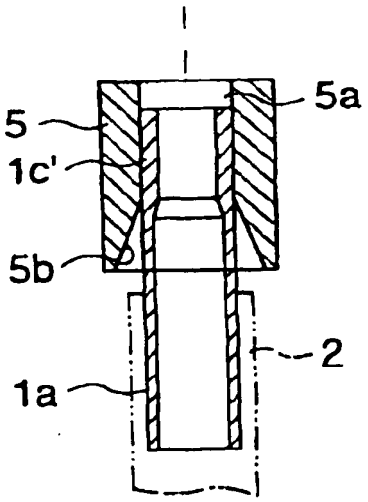


FIG. 2A

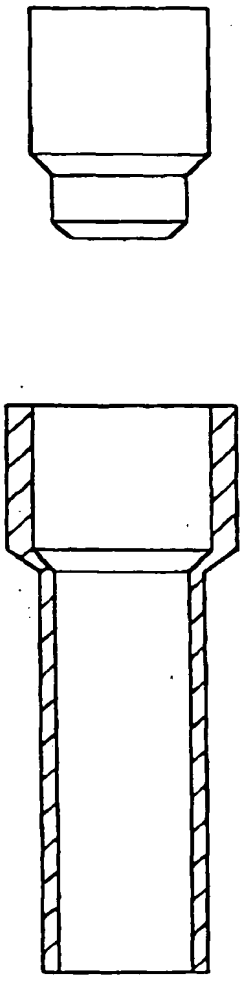


FIG. 2B

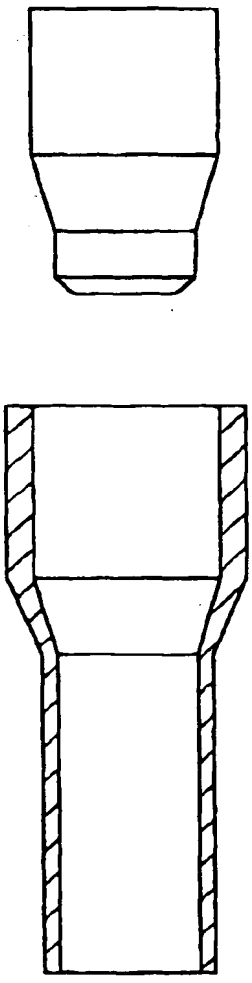


FIG. 2C

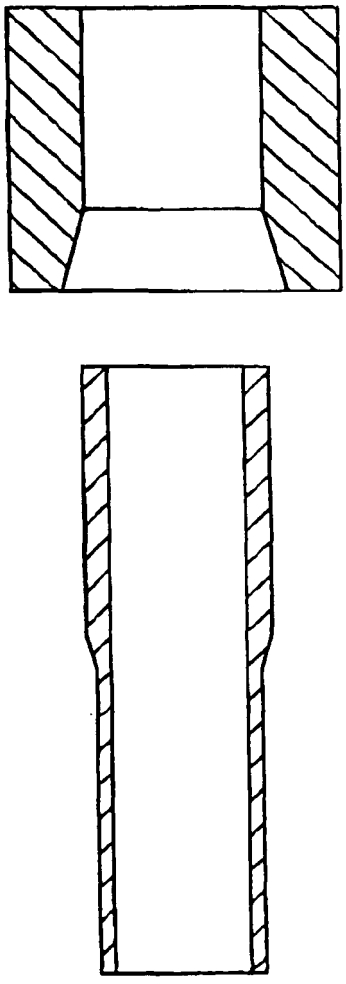
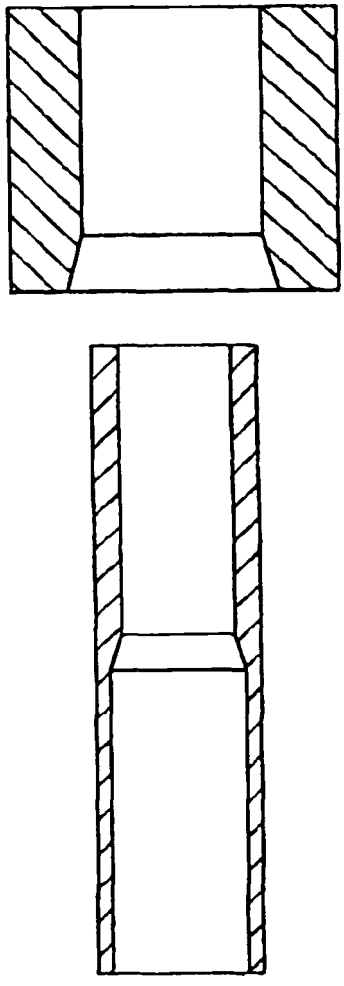


FIG. 2D



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EUROPEAN SEARCH REPORT

Application Number
EP 97 10 9237

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X A	GB 2 016 964 A (LAEIS-WERKE AKTIENGESELLSCHAFT) * abstract; claims 1,2,5-7; figures 1-5 *	1,4 2,3	B21J5/08 B21K21/12
A	FR 1 472 178 A (SOCIETE ALSACIENNE DE CONSTRUCTIONS MECANIQUES DE MULHOUSE) * the whole document *	1,4	
A	DE 37 42 496 A (NIPPON STEEL CORP.) * abstract; claims 1,2; figure 2 *	1-4	
A,D	PATENT ABSTRACTS OF JAPAN vol. 95, no. 11, 26 December 1995 & JP 07 214148 A (SANGO CO LTD), 15 August 1995, * abstract *	1-4	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B21J
B21K
B21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	11 September 1997	Cuny, J-M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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